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ROVER

KIWI-TNT EXPERIMENT

PROJECT OFFICERS REPORT—KIWI-TNT PROJECT 2.4

FIELD CHECK OF TACTICAL DOSIMETERS IM-185 (XE), INDIVIDUAL DOSIMETERS DT-236 (XE), AND OTHER DOSIMETRY SYSTEMS

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ABSTRACT

The primary objective of Project 2.4 participation in the KIWI-TNT (Transient Nuclear Test) was to test the performance of laboratory models of SEMIRAD-type mixed radiation dosimeters IM-185(XE) and experimental models of the individual dosimeters DT-236(XE). The secondary objective was to expose different types of dosimetry to establish the neutron and gamma doses at the distances at which the measurements took place. This part of the experiment was supported by Project 2.2a.

Different types of passive dosimeters and the experimental models were enclosed in containers, and each group was placed along a straight line on ground at 11 distances ranging from 23 to 400 meters.

Most of the old-type laboratory models IM-185(XE) did not work properly because the magnetic switch used in these instruments was shorted by the shock. The bellows-type switch instruments, which are a later laboratory model, did perform properly. The data analysis shows that the results obtained from the passive dosimeters agree much better for one and the same system than among different systems.

CONTENTS

CHAPTER 1

INTRODUCTION

1.1 OBJECTIVES

The primary objectives were to:

(1) Field check the performance of tactical dosimeter IM-185(XE) by exposure to a mixed neutron-gamma environment produced by KIWI-TNT (Transient Nuclear Test) radiation pulse. The total dose of interest is between 50 and 500 tissue rads.

(2) Field check the performance of individual dosimeters DT-236(XE) under similar conditions. The total dose of interest lies between 50 and 900 tissue rads each for fast neutrons and gammas. In this instrument the neutron-sensitive and the gamma-sensitive elements are completely independent of each other.

The secondary objectives were to:

(1) Expose other dosimetry systems, i.e., neutron threshold detectors, lithium-fluoride needles, Baush & Lomb (B&L) needles, tissue-equivalent ion-chamber quartz fiber dosimeters, and neutron-insensitive ion-chamber dosimeters with wall constructed of either carbon or teflon.

(2) Upon evaluation, compare the readouts of the individual systems and correlate each system with every other system to assess their reliability. Data from this project was compared with data from Project 2.2a.

1.2 BACKGROUND AND THEORY

A requirement exists for tactical dosimetry instruments that indicate both gamma and neutron doses through a direct readout system (Reference 1). The dose recorded by such an instrument must not depend on the dose rate at which the radiation was delivered. In the environment of a tactical weapon, the dose range of interest is 0 to 1000 tissue rads. The present requirement is that the tactical dosimeter should have equal response to gammas and fast neutrons, if expressed in terms of tissue rads, and should have little sensitivity to thermal neutrons. As explained in References 2-3-4, the secondary-electron mixed-radiation dosimetry system on which the IM-185 instrument is based may satisfy this requirement.

The operation of this instrument depends on the collection of low-energy secondary electrons emitted from the inside wall of an evacuated chamber by pair, by Compton or photo electrons in the case of gamma rays, and by recoil protons in the case of fast neutrons (SEMIRAD principle). No dose-rate saturation by recombination can take place here, because only electrons are collected. The linear dependence between the energy loss per unit distance traveled of a primary particle and the secondary-electron yield theoretically makes the readout proportional to delivered tissue rads and independent of the quantum energy of

the radiation. Some problems may occur in this type instrument that result from the persistent internal polarization in the insulator of the system. One of the purposes of Operation Rover was to observe and then remedy these effects.

The instruments are presently being designed by Bendix Corporation, Cincinnati Division (Reference 4), and the work is sponsored by the U.S. Air Force and the U.S. Army. While under development, the experimental models were tested in the laboratory with steady-state radiation sources for their gamma and fast-neutron response. A SPRF (Sandia Pulsed Reactor Facility) test was also performed.

The IM-185(XE) is a quartz-fiber type dosimeter, a cylinder approximately 11 cm in length and 2 cm in diameter. The instrument is activated by insertion into a portable charger. After the instrument is activated, the voltage on the quartz fiber stays constant for a considerable length of time, and the instrument is ready for exposure. During the charging operation, the air pressure in the chamber can be checked and reduced to the required value of 10^{-4} mm Hg if necessary. Test models of this instrument were available for this project. These models were calibrated in the laboratory by exposure to gamma and neutron radiations, and no calibration or recalibration

was planned on the test site.

The Army also requires an individual dosimeter (DT-236) as a supplement to the IM-185 (References 5-6). The DT-236 indicates both gamma and fast-neutron dose by means of separate elements, both of which are small solid-state devices. The sensitivity range of each is 1 to 1000 R. The gamma element is a 5-by 5-mm cylinder of silver-activated phosphate glass; the neutron element is a wide-based (1.25 mm) silicon-junction diode. The gamma element is encased in a shield made of lead, to compensate for energy dependence. The later models will also have a lithium shield to capture thermal neutrons that may cause an exaggerated gamma reading. The units exposed on KIWI-TNT did not have such a lithium shield. Both elements, plus the gamma shield, are to be encased in a tube attached to the dog-tag chain. However, in this test the container was not used.

Both elements are read indirectly, and therefore, a readout instrument (CP-696) is required. Exposure to the various types of radiation alters both types of material. The gamma element, when exposed to ultraviolet light, fluoresces, and the intensity of the fluorescence increases with dosage. The increase in intensity is read by means of a photomultiplier tube. In the neutron element, the fast

neutrons damage the crystalline structure of the base material in the diode, which causes an increase in its resistivity. The diode is read by measurement of the change in its forward voltage drop at constant-current conditions. The gamma element is insensitive to fast neutrons, and the neutron element is insensitive to gammas. The reading process does not change the dosage recorded on either element. Both elements lose a portion of the recorded dosage (recover) with time. Therefore, for testing purposes, it is desirable to read them as soon as possible after exposure and at several subsequent time intervals.

The gamma element is similar to the glass used in the Navy's DT-60, except that the mass of the glass in the DT-236 is much smaller, and therefore the light emitted is reduced. The principle used for the neutron element has been proved in three previous research contracts with Battelle Memorial Institute.

Three contracts are under way (References 7-8-9) for advanced-development models of the individual dosimeter, the reader, and epitaxially grown diodes, respectiveiy (the Electrospace Corporation diodes have diffused junctions). DT-236(XE) neutron diodes of two types and gamma-sensitive glass were available for the test. Only breadboard models of the readout devices were available at that time.

CHAPTER 2

PROCEDURE

2.1 OPERATIONS

2.1.1 Test Participation. The experiment was performed on KIWI-TNT, Operation Rover, 12 January 1965.

2.1.2 Test-Site Activities. The instruments were calibrated, wherever applicable, at U. S. Army Electronics Command Laboratories, Fort Monmouth, N.J. (USAECOM) before shipment to the Nevada Test Site (NTS). At the test site, they were inserted into containers, of which two types were used: (1) Nuclear Defense Laboratory (NDL) type, consisting of aluminum cans and covers that could be bolted on, and (2) USAECOM type, consisting of aluminum pipe sections (20 cm long by 6 cm in diameter), the sides of which could be closed with a cork. The containers were attached to a cable at distances corresponding to the station layout at the test site. After recovery by the personnel of 2.2a the containers were delivered to personnel of Project 2.4 at the Camp Mercury compound, where readings of the dosimeters were taken. For some systems (i.e., threshold detectors), no readout facilities were available at NTS, and these samples were shipped to USAECOM or Air Force Weapons Laboratory (AFWL) and evaluated upon arrival.

A readout instrument was available for evaluation of the solid-state neutron diodes. These were read 3 hours after exposure, and then at periodic intervals, to enable project personnel to observe the possibility of annealing of the radiation damage with time. Project 2.4 personnel relied strongly on the neutron and gamma data obtained by Project 2.2a to evaluate readings.

2.2 INSTRUMENTATION

Participation of Project 2.4 during Operation ROVER included the exposure of 341 dosimeters and radiation detectors of different types consisting of:

(1) Test models of the SEMIRAD tactical dosimeter IM-185.

(2) Administrative dosimeters of the phosphate-glass type, currently under development for use by the U.S. Army.

(3) Solid-state diode-type neutron detectors, currently under development. (4) Dosimetry packages to be used in the Gemini capsule by the U.S. Air Force (encapsulated low-range quartz-fiber dosimeter. (5) Experimental 600-R ionization-chamber-type dosimeters similar to the IM-93, of three different types; neutron-insensitive teflon wall type, neutron-insensitive carbon wall type, and neutron-sensitive tissue-equivalent wall type. (6) 10-R chambers on the outer stations. (7) Sulfur pellets. (8) Li^6 and Li^7 detectors. (9) Gold foils bare and cadmium-shielded. (10) Glass needles for gamma dosimetry.

Items 7 through 10 were used to obtain independent total-dose data, which were used together with the NDL data in the analysis of the results.

The ion-chamber type dosimeters and IM-185(XE) dosimeters were calibrated at USAECOM with gamma rays only. The Cs^{137} source (UDM-1A) was used. Table 2.3 shows readings obtained during Shot KIWI-TNT, together with the results of laboratory calibration.

Two sets of four neutron diodes each from the DT-236(XE) dosimeter were exposed to 2.53-MeV deuterons by the NRL 5-MeV Van de Graaff accelerator. This provided the diode calibration factor of $\Delta V = 0.207$ V per 100 tissue neutron rads. V is defined as follows: If V_1 is the voltage necessary to produce a current of 75 mA through the diode before exposure, and V_2 is the voltage necessary to produce the same current after exposure, then $\Delta V = V_2 - V_1$. This voltage is dependent on the temperature at which the reading is performed and was adjusted by means of the temperature correction shown in Figure 2.1.

It is known from previous tests that the neutron diodes are very insensitive to gamma rays, and therefore, no gamma calibration was made.

Eleven stations were used, emplaced at the same locations as the corresponding NDL Project 2.2a, Stations 6 through 16. The station configuration provided a range of distances from 23 to 400 meters (Table 2.1).

Table 2.2 summarizes the placement of dosimeters at the various stations.

The instruments were placed on sandbags, to raise them slightly above ground and thus to prevent shadow effects caused by desert rocks and irregularities of the ground. The chance of shadow effects was also reduced by the fact that the GZ was on a concrete dam above the level of the wash where the dosimeters were laid out.

After exposure, the samples were recovered by the NDL recovery crew members who pulled the cable with the attached cans into a safe area and returned them to Project 2.4 for processing.

TABLE 2.1 STATION LOCATIONS

Station	Distance from GZ
6	23
7	30
8	45
9	60
10	90
11	120
12	150
13	185
14	245
15	300
16	400

TABLE 2.2 PLACEMENT OF DOSIMETERS AT STATIONS

Station	SEMIRAD	DT-236 XE		IM-93 Type Ion Chambers										
	Dosimeters IM-185(XE)	Phosphate Glass	Solid-State Neutron	NIC 600R	NITF 600R	TEQ 600R	10 R	Sulfur Pellets	Au Foil (bare)	Au in Cd Shield	B&L Glasses Needles	Li^6 Li^7 rods	Gemini Capsules
6	-	4	4	-	-	-	-	2	-	-	1	6	-
7	-	4	4	-	-	-	-	2	-	-	1	6	-
8	-	4	4	1	-	-	-	2	-	-	1	6	-
9	2	4	4	1	1	1	-	2	1	1	1	6	-
10	3	4	4	1	1	1	-	2	1	1	1	6	-
11	5	4	4	1	1	1	-	2	1	1	1	6	-
12	5	4	4	1	1	1	-	2	1	1	1	6	-
13	3	4	4	1	-	1	-	2	1	1	1	6	-
14	2	4	4	1	-	1	2	2	1	1	1	6	-
15	-	4	4	-	1	-	2	2	1	1	1	6	-
16	-	4	4	-	1	-	2	2	1	1	1	6	-

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TABLE 2.3 TEST SITE READINGS AND LABORATORY CALIBRATION OF ION-CHAMBER DOSIMETERS AND IM-185(XE) DOSIMETERS CALIBRATED AT USAECOM WITH Cs^{137} SOURCE

Station	Dosimeter	Zero Reading	Final Reading	Calibration Factor	Actual Reading
		Divisions	Divisions	R/division	R
10	TEQ 42 600R	-1	56	200/33	345
10	NIC 116 600R	2.5	42	200/33	239
10	NITF 2 600R	0	50	200/34	294
11	IM 185 004	6.5	60	Erratic Calibration	
11	NITF 110	-1	27	200/34	165
11	NIC 14	0	32	200/38	165
12	NITF 107	0	17	200/39	87
12	NIC 4	1	19	200/36	100
12	TEQ 37	-1	20	200/28	150
12	IM 185 0002	2.5	27	200/29	170
13	NIC 1	-1	12	200/46	56.5
13	TEQ 33	0	11	200/25	88
13	IM 185 201	75	315	300/600	120
14	NIC 111 600R	0	5	200/33	31
14	TEQ 19	1	5	200/32	25
15	NITF 1	.0	4	200/45	17.8
16	NITF 3 600R	1	3	200/37	10.8
	Bendix 4529 10R	0.2	6.6	1.05	6.72
	Bendix 4437	0	6.6	1.22	8.05

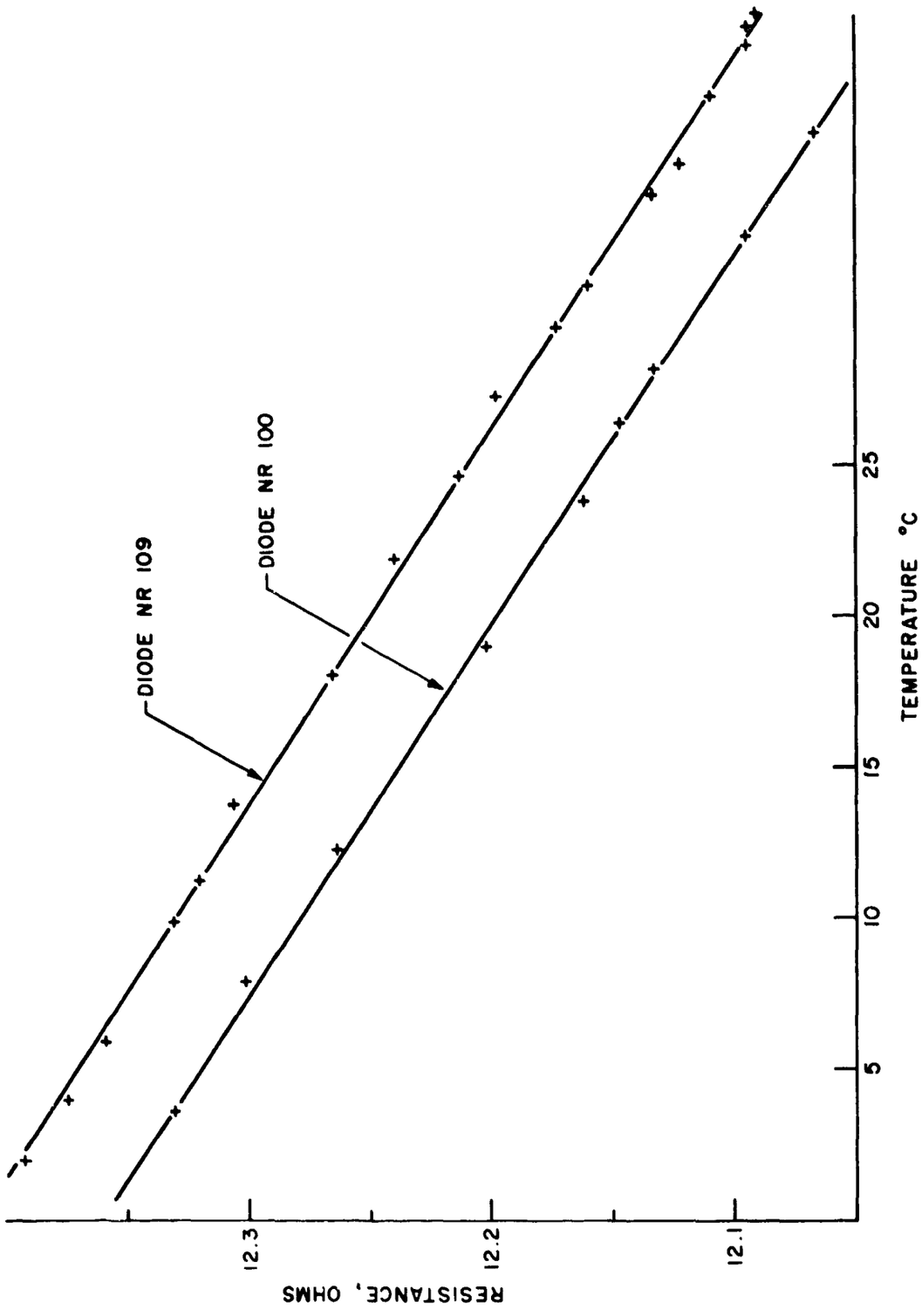

Figure 2.1 Variation of resistance with temperature (Diodes 100 and 109).

CHAPTER 3

RESULTS

The data obtained from the different models of dosimeters is listed in Table 3.1. For correlation purposes, the data obtained at the same stations by Project 2.2a are listed in Table 3.2. The columns showing true or most reliable estimate of total dose for neutrons, gammas, and mixed radiation were obtained by averaging overall measurements for each station (Table 3.3). This table also lists separately for each station the standard deviation obtained from all gamma-dosimetry systems used on Projects 2.2a and 2.4. These standard deviations should provide a measure of reliability of gamma-dose measurements.

All Project 2.4 gamma measurements are in roentgens and are based on calibration exposure of the same dosimeter types to gamma radiation from AFWL's 124-curie Cs^{137} source. The accuracy of the B&L needle readings, based on this calibration is estimated to be ±12 (1 sigma) in the 0-2 100-R range, ±4.5 (1 sigma) from 100 to 1000 R, and ±5.5 (1 sigma) from 1000 to 6000 R. The accuracy of the Li^7F dosimeters is estimated to be ±18 (1 sigma) in the 0-2 100-R range, and ±9 (1 sigma) in the 100-2 6000-R range.

The sulfur pellet doses are given in terms of total

neutron fluence of energy exceeding 2.5 MeV an effective cross section for the S^{32} (n,p) P^{32} reaction is used, which assumes that the KIWI-TNT's fast-neutron spectrum has the same shape above 1.58 MeV as does Godiva II (i.e., the Watt spectrum). The absolute accuracy of the sulfur-pellet dose is (if the Watt-spectrum assumption is correct) approximately ±10.

The gold and the gold-cadmium doses are given in terms of neutron fluence. The bare gold measurements include both thermal and epicadmium neutrons. The gold-cadmium measurements include only epicadmium neutrons, particularly neutrons at the 5-eV gold activation resonance. The thermal fluence at any station is simply the difference between the gold and the gold-cadmium fluences. The absolute accuracy of the gold-foil measurements is probably about ±10.

The self-indicating ionization-chamber readings reported have been corrected for calibration on Cs137.

Unfortunately, no dose interpretations can be made from the natural LiF dosimeters exposed at KIWI (i.e., the 6000 series of LiF), because the readout system was not under control at the time they were read out, and the readout procedure is destructive.

The burst time used for all sulfur and gold computations

was 12 January 1965, 11h 57m 46s. Experimental models of the IM-185 were exposed. Of these, five were overexposed. These five units were located at Stations 10 and 11 (see Table 2.2) where the total radiation dose was greater than the range of the instruments, and therefore, no conclusion can be reached concerning their performance.

The remaining units consisted of two types of experimental models of IM-185(XE). One type, which was an earlier experimental model, had a magnetic switch consisting of a piece of iron wire suspended on a hairspring. The other type had a bellows-type switch similar to the standard ion-chamber type quartz-fiber dosimeter IM-93. Only three units of the bellows-type switch were among the properly exposed instruments. All models having the magnetic switch failed. The shock wave and the subsequent dragging of the cans on the cable over desert rocks resulted in a momentary short circuit of the switch; thus, the quartz fiber went off-scale, and the results were lost. Later, this switch-closing effect was investigated at USAECOM by exposure of the dosimeters to sudden shock. The results agreed with the effects experienced at NTS.

Only three SEMIRAD-type dosimeters (Stations 11, 12, and 13) gave readings on-scale, but one of these units showed a most erratic behavior during calibration, and therefore, this reading

must be discarded. In total, only two SEMIRAD readings were obtained. Both of them agree well with the expected total-dose data (See Tables 3.1 and 3.3). On many ion-chamber type quartz-fiber instruments, the reading was off-scale also. This effect was attributed to an anticipated over-exposure, as in the case of IM-185, or in some cases to failure of the bellows-type switch, which discharged the quartz fiber during accidental closing.

The shock wave following the explosion was much stronger than anticipated and resulted in some damage to instrumentation. Some of the lead enclosures surrounding the phosphate-glass dosimeters became shattered at the stations close to GZ.

To understand the test results better and to display them properly, each dosimetry system was considered individually. Each system was evaluated by the mean of the least-squares deviation as follows: Each of the sets of experimental data was assumed to have a form

$$D = \frac{Ae^{-uX}}{X^2}$$

where D is the dose in rads, and X is the distance in meters, A and u are constants to be determined. Multiplying by X^2 and taking the natural logarithm, produces the following

equation

$$\log_e(DX^2) = uX + \log_e A$$

which is the equation of a straight line with a slope of -u.

A graph has been drawn of $\log_e(DX^2)$ versus X for each type of instrument. Each graph includes the following information: (1) the experimental data represented by points; (2) a solid line that is the best fit of the experimental data; the method of least squares with equal weights for all data points is used according to the above expression; (3) the root-mean-square deviation of the data from the straight line (vertical line); (4) the equation of the least-squares fit of the data, which includes the root-mean-square deviation; and (5) a dotted line that has a slope corresponding to a folding distance of $350\ m^{-1}$ for gamma-sensitive instruments, 220^{-1} for neutron-sensitive instruments, and 285^{-1} for instruments that are both gamma-and neutron-sensitive. These folding distances, which are typical for air, are only for purposes of comparison, and should not be interpreted as the true values for this experiment. This line agrees by definition with the neutron, gamma, or mixed dose obtained by averaging the results of different systems at Station 6 (see Table 3.3).

The following comments can be made as the result of the

mean least-square analysis. Lithium fluoride agrees well and has low scattering but gives a dose reading that is slightly high (Figure 3.1). The same applies for B&L needles and the tissue-equivalent ion chamber (Figures 3.2 and 3.3). The gamma-sensitive carbon ion chamber and teflon ion chamber show, surprisingly, a saturation effect that cannot be explained away by ion recombination but may result from poor statistics of the measurement (Figures 3.4 and 3.5). The low-dose Bendix ion chamber, which is sensitive to neutrons and gammas, shows an effect opposite to saturation and a very small amount of data scattering (Figures 3.6). The gamma part of the DT-236(XE) gave doses which are too high but show little data scattering. The obvious reason for this behavior is the effect produced by thermal neutrons. The neutron part behaved comparatively well (Figures 3.7 and 3.8).

A similar analysis was made for the data of Project 2.2a, and the results were used in the preparation of Table 3.3.

Among the data presented above, many curves show a curvature that results in an apparent maximum in the dose at about 100 m from GZ. The origin of this effect is uncertain, but it may possibly be explained by buildup effects.

The personal dosimeter DT-236XE performed comparatively well on fast neutrons but showed high results for gamma radiation.

The IM-185 with magnetic switch was overly sensitive to shock (confirming laboratory tests), but two instruments with bellows-type switches gave satisfactory readings of the mixed neutron-gamma dose.

A comparison of several field dosimetry systems showed the probable errors to range grom 10 percent to 52 percent, with a standard deviation of 22 percent. The deviation of each system individually was less than 22 percent.

The data obtained from different dosimetry systems when averaged out for each station are quite disturbing. As evident from Table 3.3, the percentages of probable error range between 10 and 52, with the average standard deviation being 22. The best available systems were used, and the systems which might be questionable were not processed in the computation of standard deviation. Therefore, it may be concluded that the field of dosimetry is by far less reliable than hoped. The data agree better with each other if one and the same system is considered, but comparison of two or more different systems gives a much bigger deviation from each other than expected. Adherence to one system improves the results only apparently and may provide an unjustified sense of security concerning the results.

Figures 3.9 and 3.10 show the average gamma dose and average neutron dose.

TABLE 3.1 DATA OBTAINED FROM DIFFERENT DOSIMETRY SYSTEMS BY PROJECT 2.4

Station	Distance	Li^7F(Av. of 6 Samples)	B&L Needle	Tissue Equivalent Ion Chamber	Carbon Ion Chamber	Teflon Ion Chamber	Radiacmeter IM-185(XE)/UD SEMIRAD Chambers	Bendix 686 or 608 Ion Chamber
	m	R	R	R	R	R	R	R
6	23	5740	5710					
7	30	3565	3940					
8	45	1118	1600					
9	60	924	1078					
10	90	338	430	345	239	294		377
11	120	174	221		168	165		190
12	150	126	159	150	100	87	170	92.2
13	185	55	58.1	88	56.5		120	
14	245	30	34.0	25	31			
15	300	15.7	17.7			17.8		
16	400	6.1	12.5			10.8		7.7

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TABLE 3.1 DATA OBTAINED FROM DIFFERENT DOSIMETRY SYSTEMS BY PROJECT 2.4 (Contd)

Station	Distance	DT-236 (Special $AgPO_3$ Glass	DT-236 (Special) Neutron Diodes	Sulfur	Gold (bare)	Gold in Cd Shield
	m	R	rads	n/cm²	n/cm²	n/cm²
6	23	6930	3050	1.06×10^{11}		
7	30	5650	2280	6.38×10^{10}		
8	45	2370	928	3.11×10^{10}		
9	60	1530	440	1.72×10^{10}	5.76×10^{11}	3.63×10^{11}
10	90	611	164	6.15×10^{9}	2.61×10^{11}	1.74×10^{11}
11	120	343	87	3.24×10^{9}	1.35×10^{11}	9.15×10^{10}
12	150	179	45	2.72×10^{9}	7.78×10^{10}	4.80×10^{10}
13	185	113	29.5	1.06×10^{9}	4.37×10^{10}	2.4×10^{10}
14	245	58		6.0×10^{8}	1.84×10^{10}	1.20×10^{10}
15	300			2.7×10^{8}	9.09×10^{9}	6.01×10^{9}
16	400			2.2×10^{8}	2.8×10^{9}	1.9×10^{9}

TABLE 3.2 DATA FOR GAMMA RAYS FROM NDL PROJECT 2.1

Station	Distance	Cobalt Glass Li^6 Shield	$AgPO_3$ Glass (Fluorescence) Li^6 Shield	High Z $AgPO_3$ Glass ORNL Shield	Low Z $AgPO_3$ Glass ORNL Shield	CaF TLD EDS	Film 649-0 or 508 NBS Holder	Film 510 NBS Holder	Film 1290 NBS Holder
	m	R	R	R	R	R	R	R	R
6	23	3940	4140	3640	3940	3320	2580		
7	30	3210	2460	3360	3760	2820	2960		
8	45	1330	1680	1380	1280	1060	1940		1740
9	60		912	982	832	659			939
10	90		454	447	264	280			398
11	120		384	271	138	156			223
12	150		105	129	93.8	88.6			120
13	185		59.2	49.3	29.3	51.8			71
14	245					26.5		34	33
15	300					14.3		20	16
16	400					6.3	3.6	1.5	6.6

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TABLE 3.3 TRUE TOTAL DOSE AND STANDARD DEVIATION

Station	Distance	True Total Dose Based on Project 2.2a			Standard Deviation for all Gamma Dosimetry Systems		
		Neutron Dose (Foils) from Proj. 2.2a only	Average Gamma Dose (Except DT-236)	Average Gamma (Except DT-236) plus Neutron Dose	Absolute	Percent	Number of Data Points Used
	m	Tissue rads	Tissue rads	Tissue rads	Tissue rads		
6	23	3930	4126	8056	1028	25.0	8
7	30	2710	3259	5969	466	14.3	8
8	45	1150	1458	2608	281	19.3	9
9	60	680	904	1584	121	13.4	7
10	90	267	343	616	79.4	22.8	9
11	120	148	211	359	72.6	34.4	9
12	150	82.2	112	194	22.2	19.8	9
13	185	65.8	53.8	120	11.1	20.6	8
14	245	18.5	31.4	49.9	2.6	8.3	6
15	300	3.42	16.9	20.0	1.8	10.6	5
16	400	0.74	6.77	6.9	3.5	52.0	6

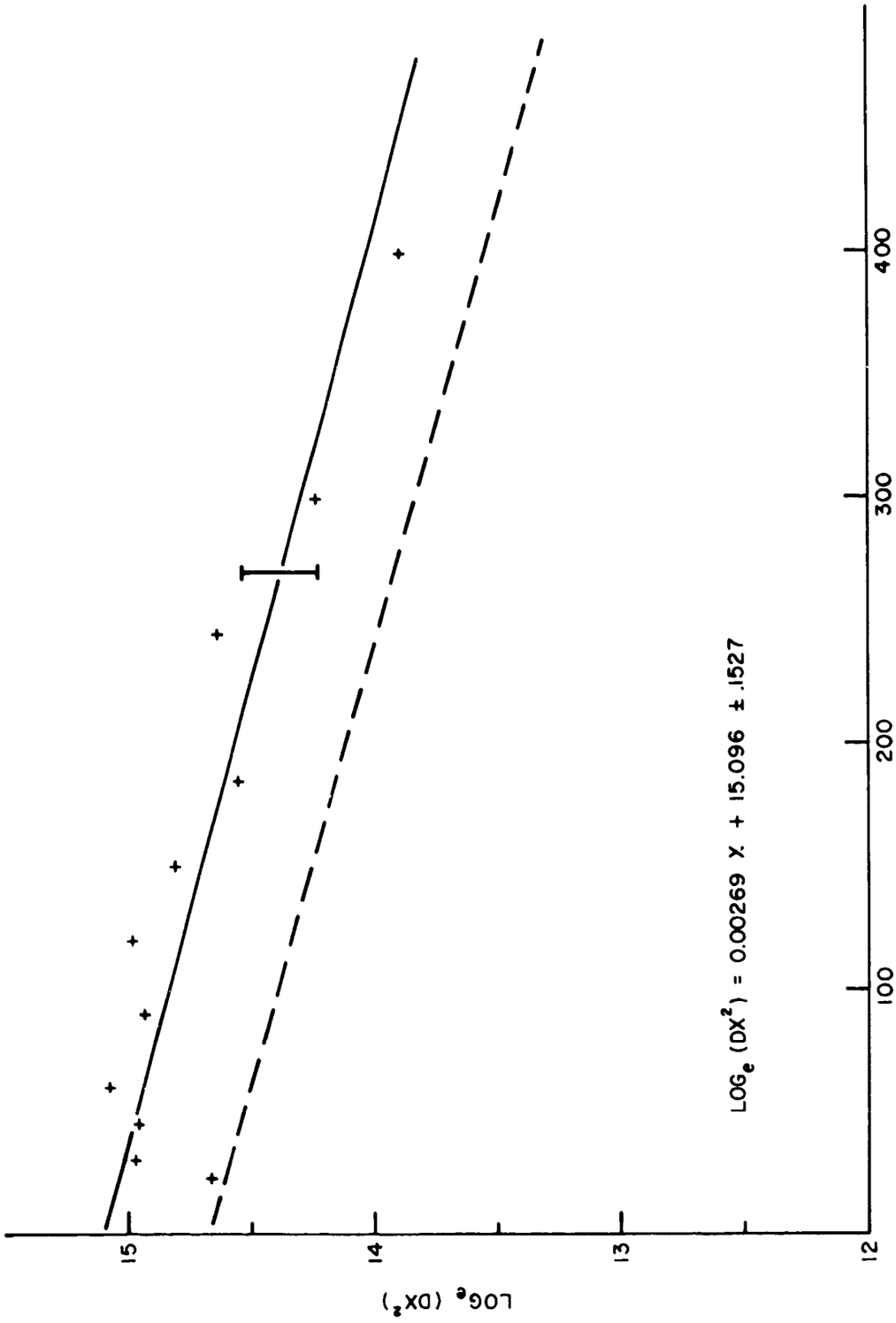

Figure 3.1 Curve of $\log_e(DX^2)$ versus X, lithium fluoride (gammas).

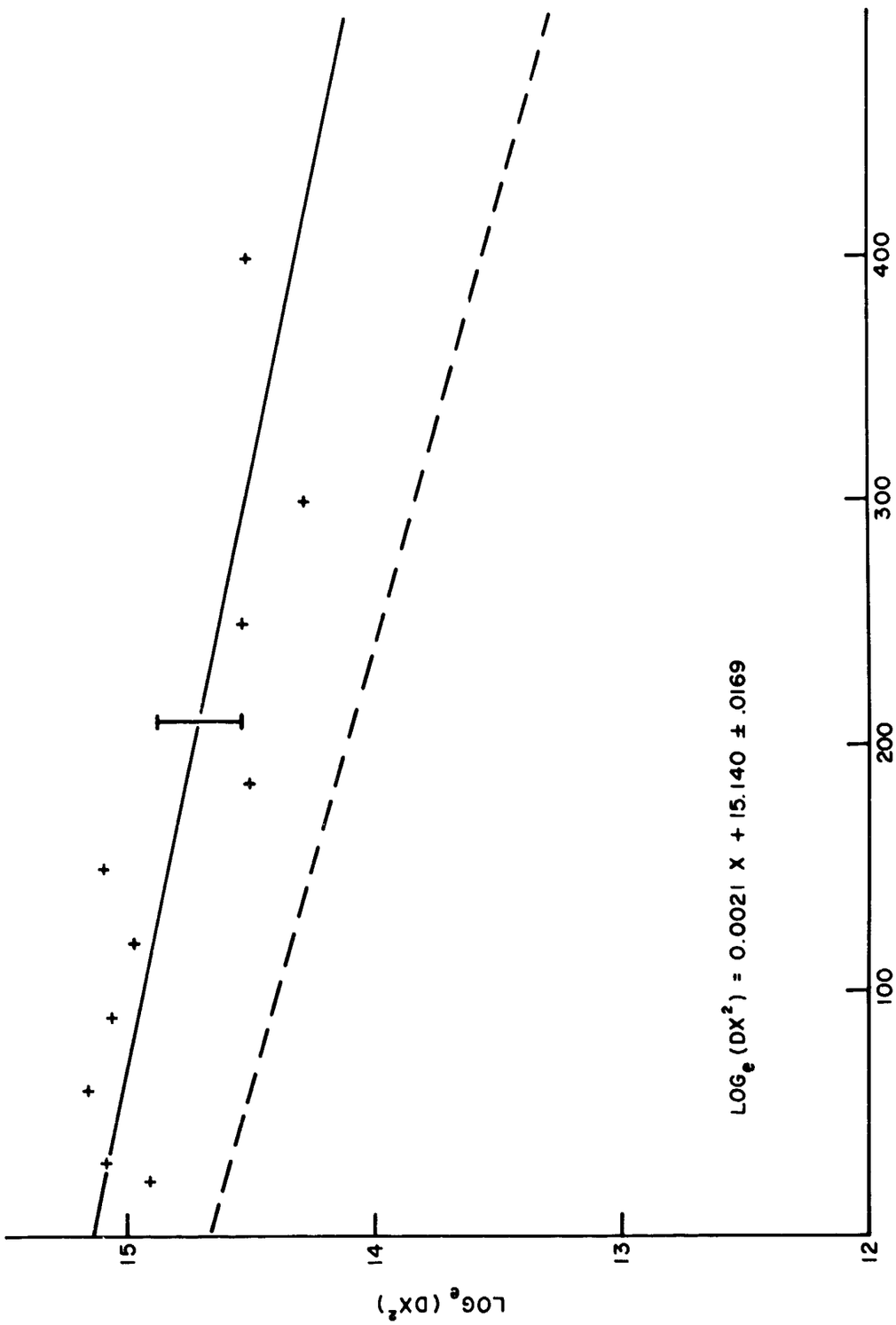

Figure 3.2 Curve of $\log_e(DX^2)$ versus X, B&L needles (gammas).

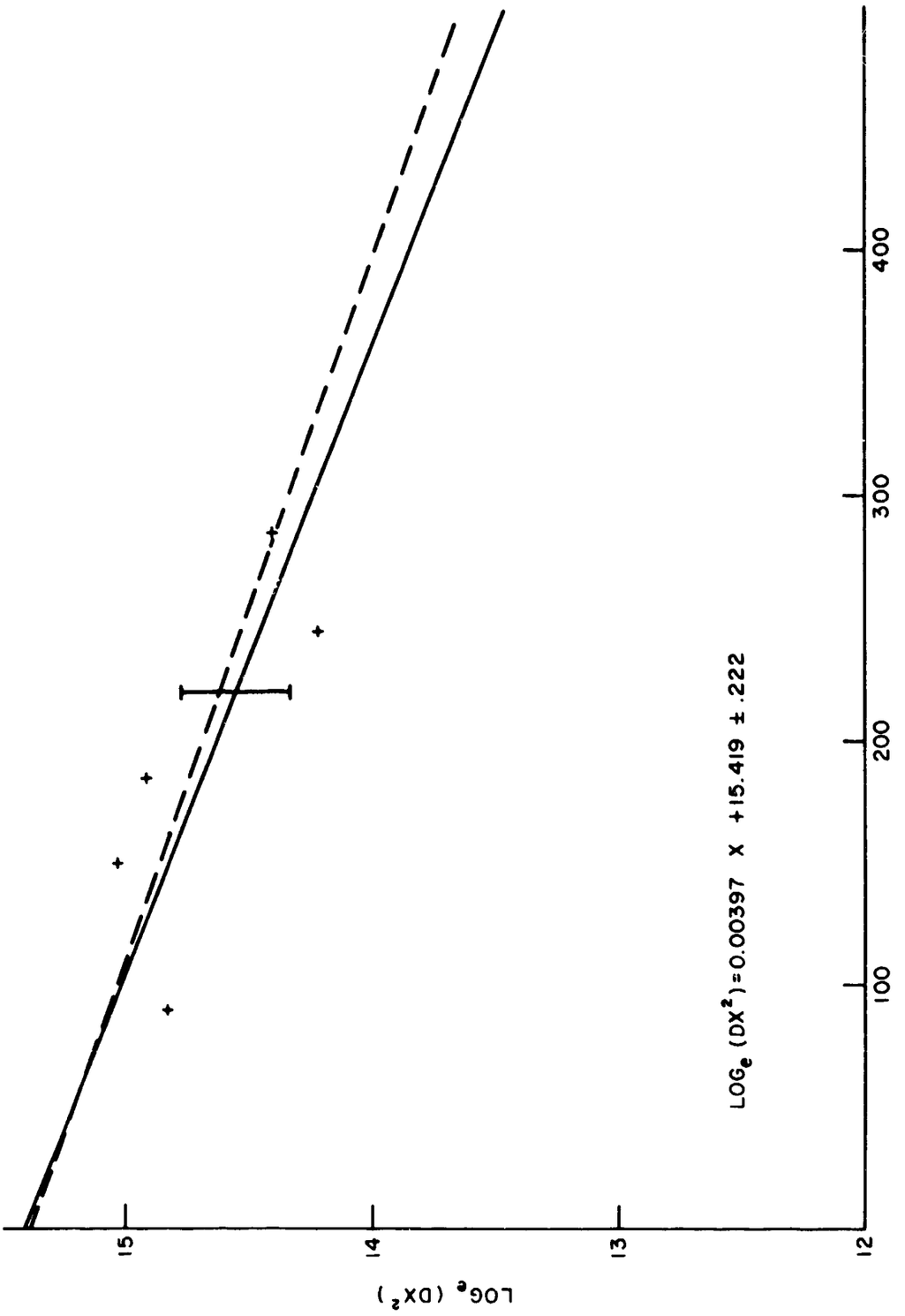

Figure 3.3 Curve of $\log_e(DX^2)$ versus X, tissue-equivalent ion chamber (fast neutrons and gammas).

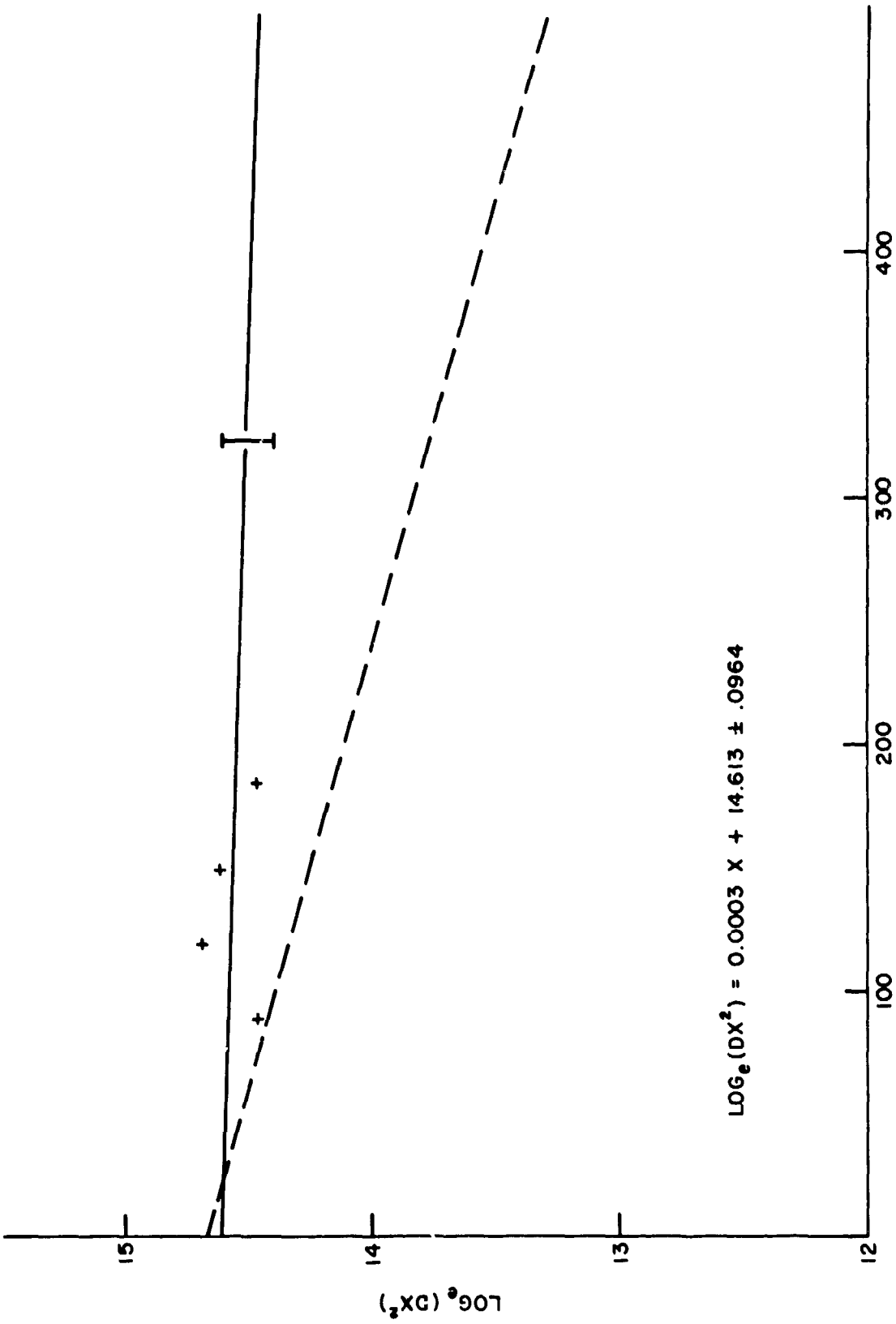

Figure 3.4 Curve of $\log_e(DX^2)$ versus X, carbon ion chamber (gammas).

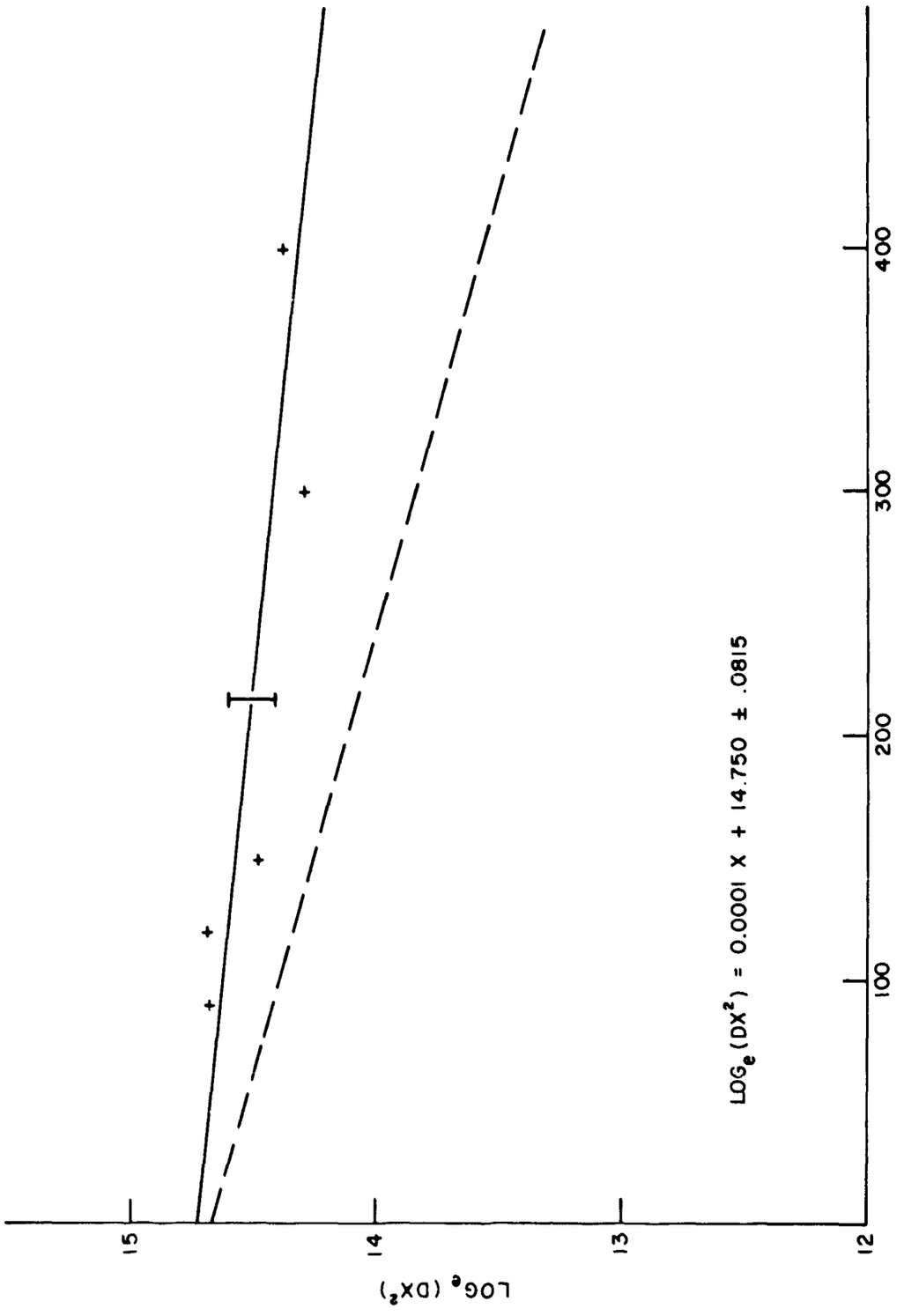

Figure 3.5 Curve of $\log_e(DX^2)$ versus X, teflon ion chamber (gammas).

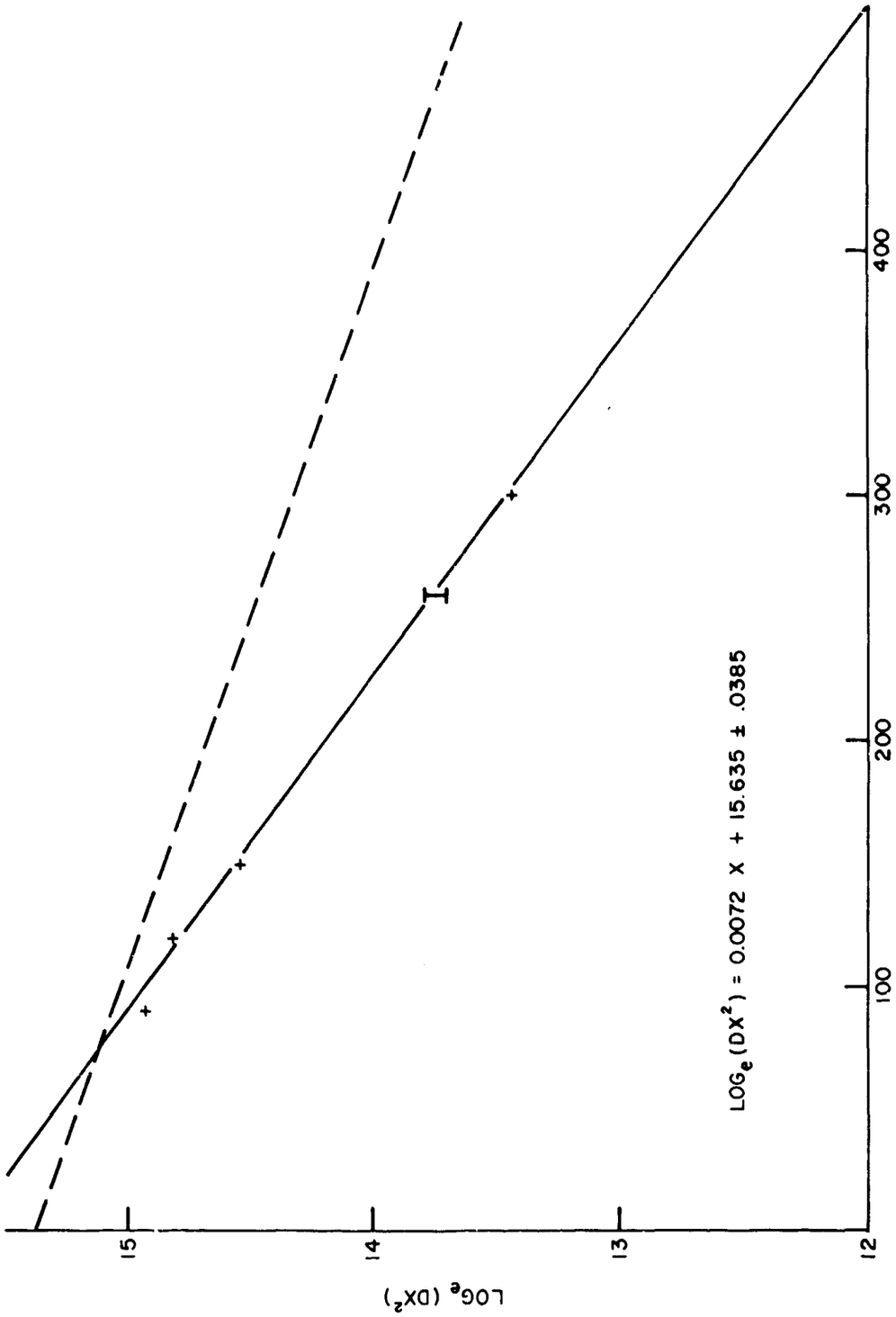

Figure 3.6 Curve of $\log_e(DX^2)$ versus X, Bendix ion chamber (fast neutrons and gammas).

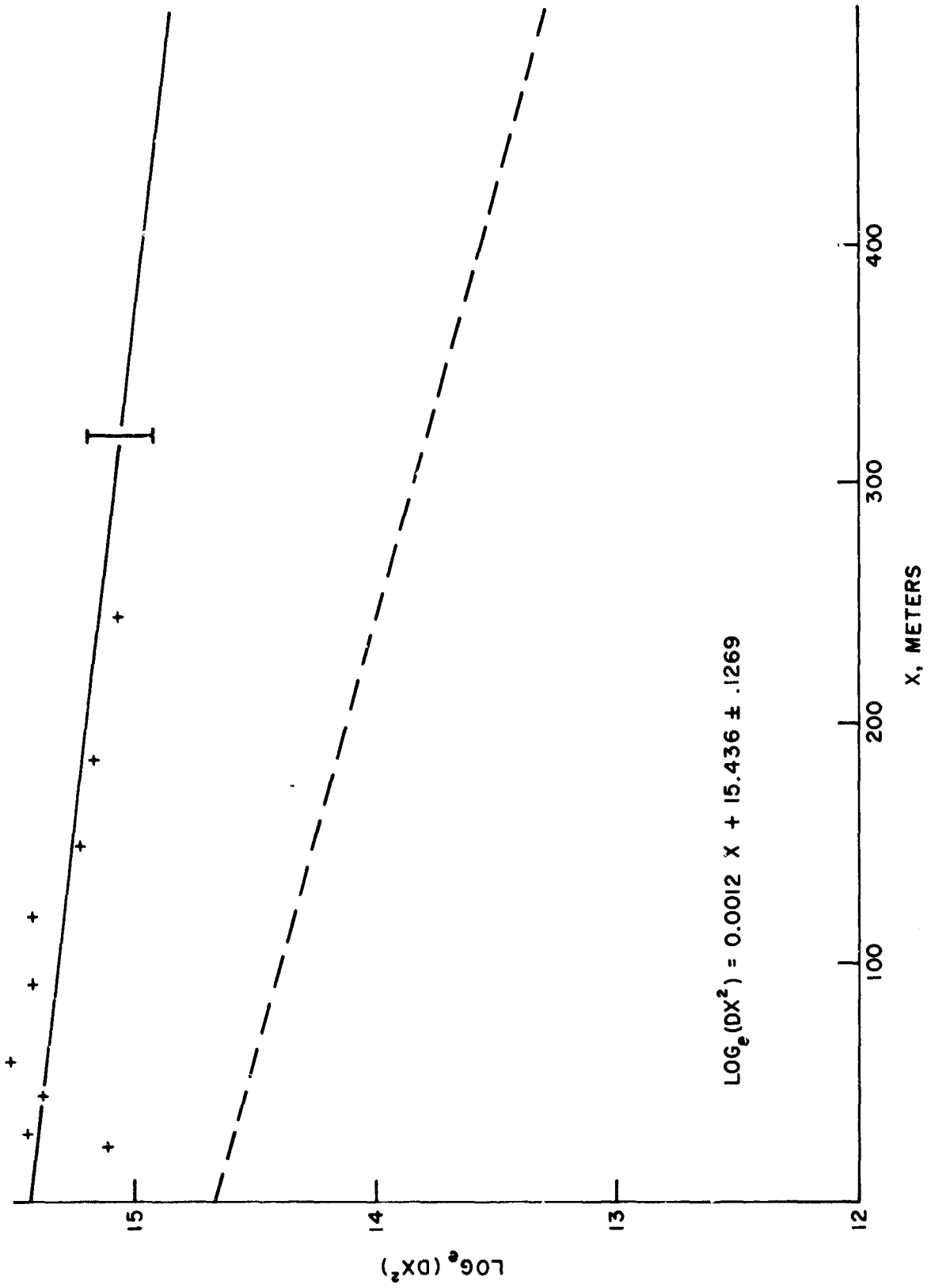

Figure 3.7 Curve of $\log_e(DX^2)$ versus X, DT-236 (gammas).

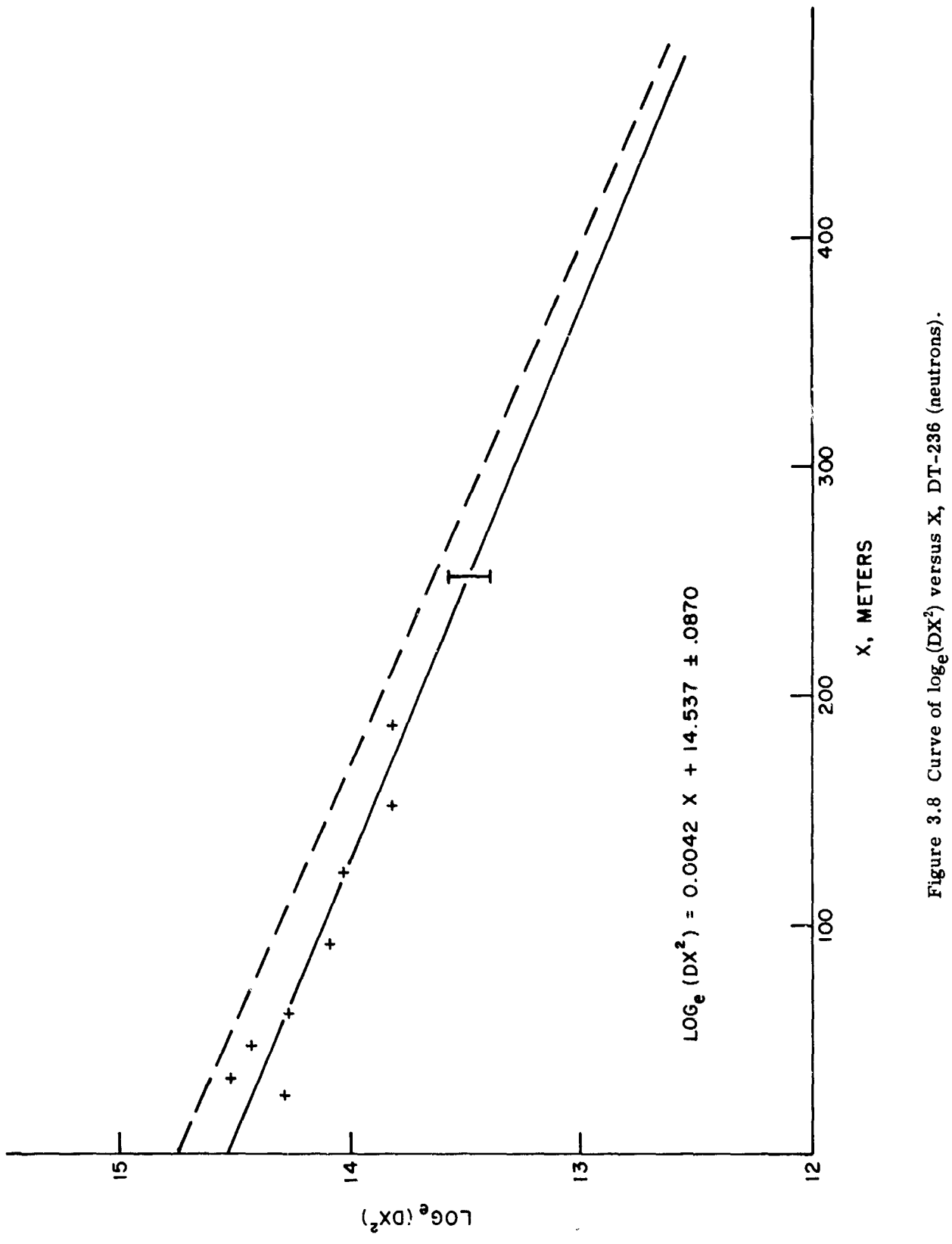

Figure 3.8 Curve of $\log_e(DX^2)$ versus X, DT-236 (neutrons).

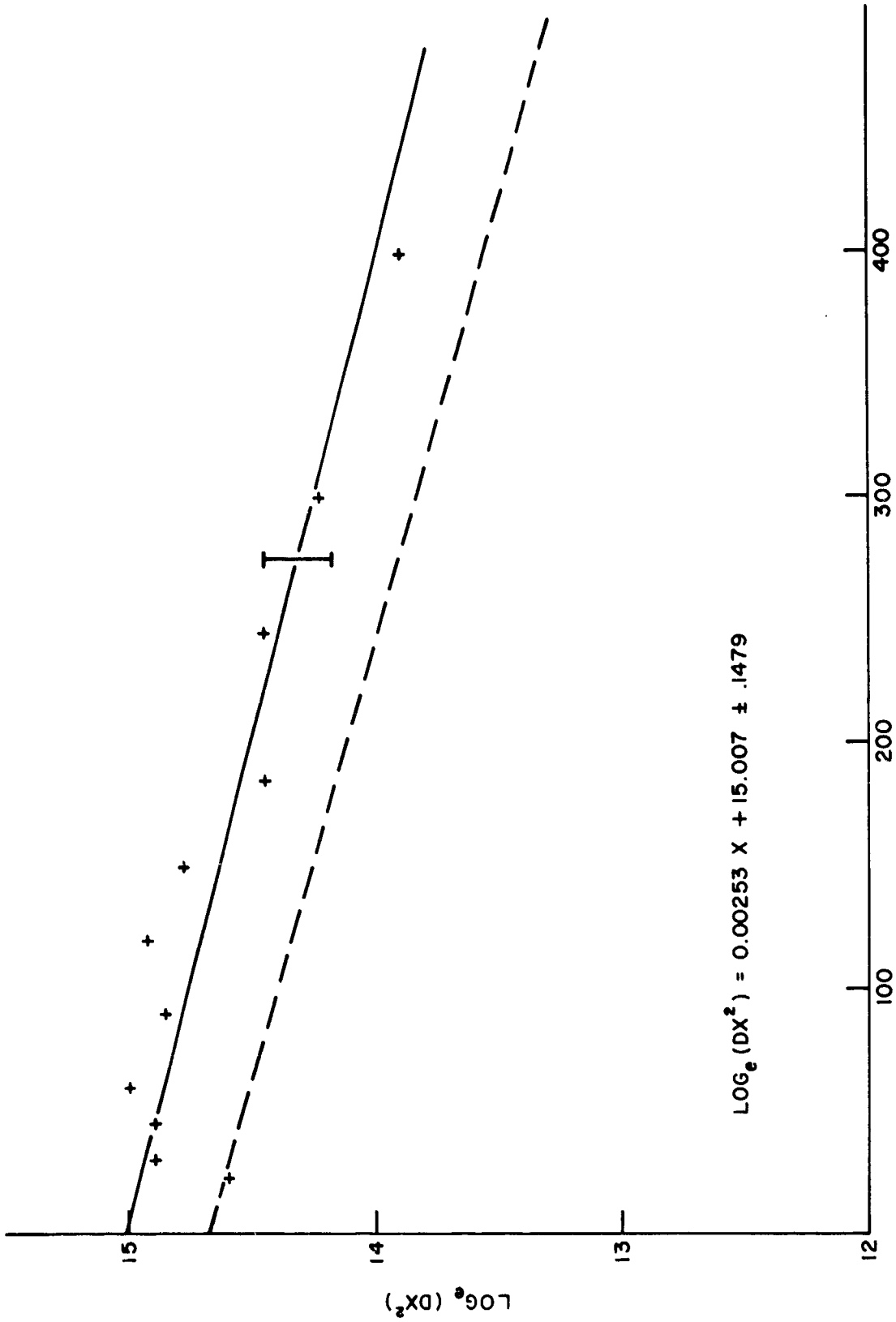

Figure 3.9 Curve of log$_e$(DX^2) versus X, showing average gamma dose from all instruments except DT-236.

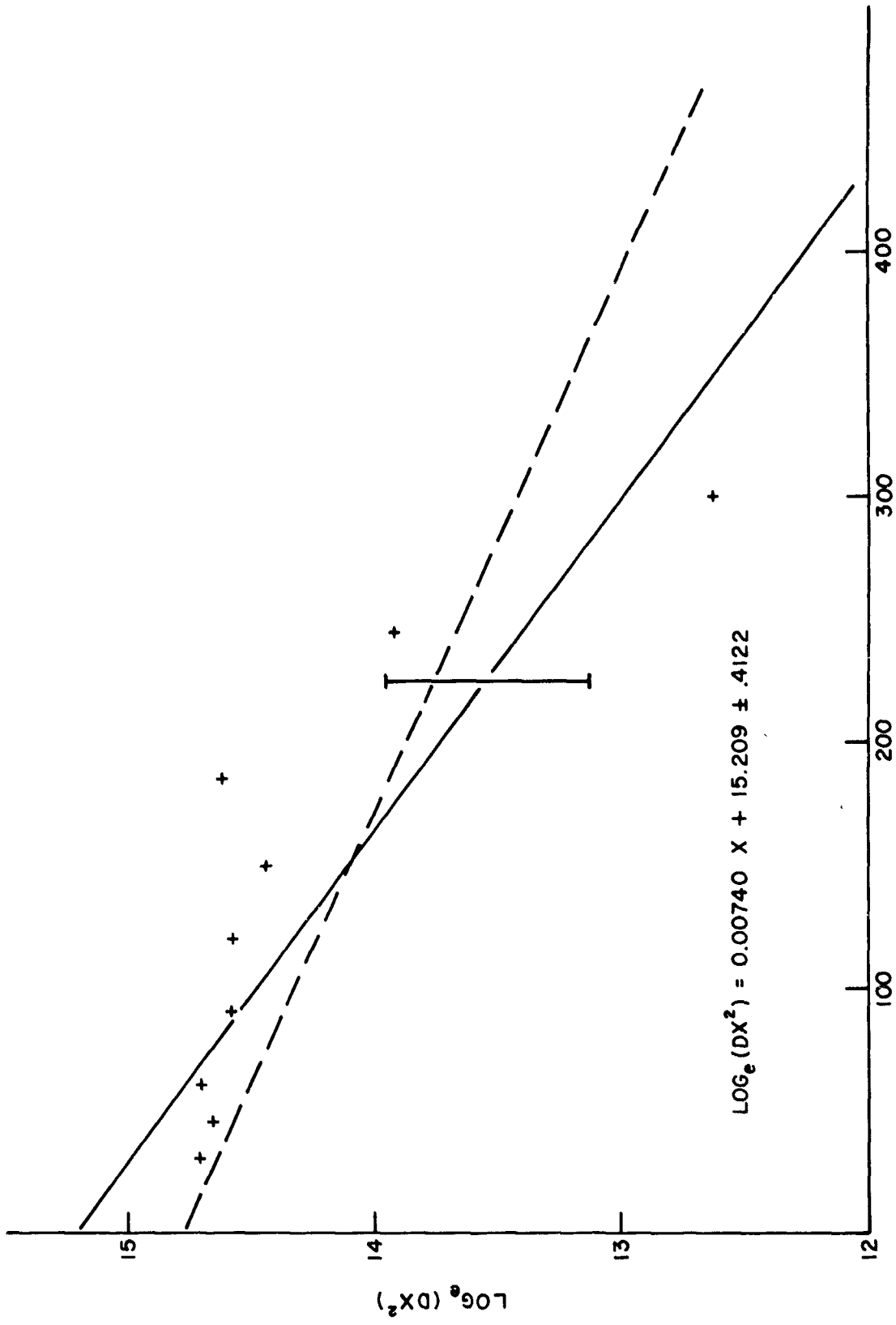

Figure 3.10 Curve of $\log_e(DX^2)$ versus X, showing average neutron dose from all instruments.

CHAPTER 4
CONCLUSIONS

The required accuracy of both tactical and personal dosimetry in field use by the Army is spelled out in References 1 and 5. According to Reference 1, this accuracy should be ±10. As is evident from the above data, this accuracy could not quite be obtained even when the best scientific methods were used, and probably the problem would be much more serious if the measurements had been obtained in the battlefield by a fighting army. Therefore, satisfaction of this accuracy requirement should presently be considered as a wide-open case.

The KIWI-TNT test was not designed to reveal any data concerning the saturation properties of the dosimetry system, because the dose rates encountered there were relatively low. For this reason, the apparent saturation effects observed on some of the quartz-fiber dosimeters are most disturbing. They cannot be explained by means of Boag's theory on ion recombination. Another explanation may be found for these effects at a later time: for example, radiation effects on the condenser that is used in the instrument to extend its range.

CHAPTER 5

RECOMMENDATIONS

After further laboratory research on both personal and tactical dosimeters, and after thorough laboratory testing and exposure, it is recommended that the newly developed units, together with other more conventional dosimetry systems, undergo further testing. Experiments of the KIWI-TNT type should be repeated. However, it would be preferable to test the systems on experiments that produce a high-intensity environment, similar to a small tactical weapon burst above ground. Such experiments could be used to check the saturation characteristics of the different dosimetry systems.

To resolve the problem of precision (scattering of data within one and the same dosimetry system) versus accuracy (scattering of data between different systems), the use of an absolute dosimeter such as a calorimeter is recommended. Such instruments are presently available, but they should be modified for field application in future tests.

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14 October 1998

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POR-6102 AD-488355L
Operation ROVER KIWI-TNT Experiment,
Project Officers Report – KIWI-TNT Project 2.4,
Field Check of Tactical Dosimeters IM-184 (XE),
Individual Dosimeters DT-236 (XE), and Other
Dosimetry Systems, Issuance Date: September 9, 1966.

Distribution statement **"A"** now applies.

Ardith Jarrett

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Chief, Technical Resource Center